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by

Kenneth B. Trousdell

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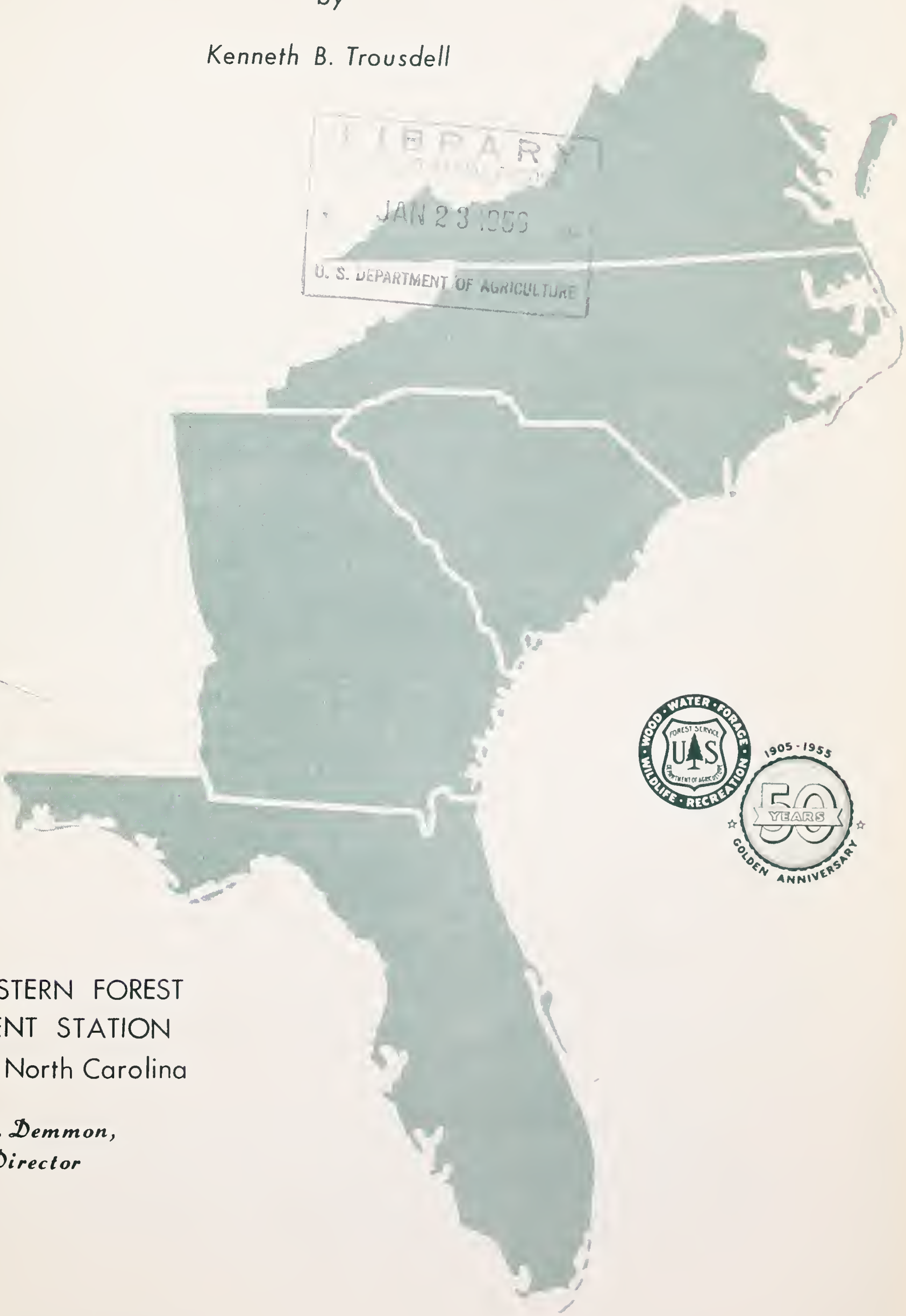

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

E. L. Demmon,
Director

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

LOBLOLLY PINE SEED TREE MORTALITY

By
Kenneth B. Trousdell

To keep the land in continuous production, the seed-tree method of cutting is commonly used in loblolly pine stands of the coastal plain of North Carolina and Virginia. By this method selected trees are left standing for varying lengths of time after logging to furnish seed for the next generation of timber. The main body of this paper is concerned with the rate and extent of loss of these valuable seed trees through mortality from various causes as observed in a large-scale test of different management systems on the Bigwoods Experimental Forest[1/] from June 1948 to October 1954. The damage done later by a recent hurricane is discussed separately to show the effects of this storm on seed-tree stands.

This study shows that more seed trees die during the first few years following logging or major cultural measures than in later years. Some of the early mortality is associated with tree injury or change in environment that occurs during logging or cultural treatment. This mortality can be decreased by more careful logging and less severe cultural treatments. After two or three years the principle causes of tree mortality are lightning and wind. Mortality from the latter causes will continue as long as the seed trees stand above the young forest. Leaving 2 trees per acre to insure seed in case of a wildfire is not enough, and thus the practice is not recommended.

THE STUDY AREA

The Bigwoods Experimental Forest is a 1365-acre tract which was well stocked with mature loblolly pine when it was established in 1945. The forest was divided into 37 compartments, each with an area of about 35 acres, in a comprehensive test of different methods of even-aged and many-aged management. On 22 areas seedling stands were established by natural seeding following seed-tree or alternate-strip cuttings. Eight large, well-spaced, seed trees were left per acre on 14 of these compartments. The 8 additional areas were cut by the alternate-strip method. Strips 1 chain wide were left as a seed source and intervening strips 3 chains wide were clearcut. After the resultant seedling stands from either of these cutting methods were judged to be satisfactory, a second cut was made removing all merchantable pines except 2 trees per acre which were termed "insurance trees."[2/]

[1/] Maintained by the Southeastern Forest Experiment Station in cooperation with Camp Manufacturing Company, Inc., Franklin, Virginia.

[2/] In the remainder of the text, the term seed trees refers to trees left in stands of 8 per acre, and the term insurance trees refers to trees left in stands of 2 per acre after removal of the seed source.

During the period of June 1948 to October 1954 a record was kept of the pine seed trees left standing on each area until the trees were harvested. Trees that died were recorded by size and suspected cause of death. The final inventory of tree mortality was made on all areas in October 1954. A total of 3,802 seed trees on 494 acres were left for an average period of 3.3 years, and 1,291 insurance trees on 674 acres were left for an average period of 2.1 years. In the seed-tree stands the average tree was 19.7 inches d.b.h. with an estimated volume of 520 board-feet per tree. The insurance trees were smaller, averaging 17.2 inches d.b.h., with an estimated volume of 360 board-feet per tree.

TREE INJURY AND SUSPECTED CAUSE OF MORTALITY

In spite of careful supervision when the stand was cut, 8 percent of our seed trees were severely damaged in the felling operation or during tractor logging. The majority of the damage (6 percent) occurred at the base of the trees and was caused by the skidding operation. A tree that was barked a minimum of 10 inches or 1/3 of the circumference was classed as severely damaged. Severe felling damage (2 percent) included all trees barked along the main bole or having a major limb broken in the crown. Logging damage has been the apparent cause of death of 5 percent of the injured trees.

In one winter logging operation, the heavy soil was churned into mud at a loading point and 6 seed trees located in the area died. Severe mortality has been observed on other cutover tracts following tractor logging on poorly drained plastic soils when the water table was near the surface. This type of damage has been reported by McCulley.[3]

A fire treatment designed to improve the seedbed for pine regeneration was used on half the areas. In this treatment, the cutover area was burned after logging and prior to seedfall. The post-logging fires usually generated hot columns of air from slash concentrations and resulted in occasional crown scorch. Most of the severely scorched trees died. To our knowledge no large pine was killed primarily by heat at the base of the tree.

In assigning a primary cause for tree mortality, the recorder used his best judgment. Dead trees that had visible signs of injury by fire, logging, lightning, or wind were listed under the appropriate cause (table 1).

This simple enumeration of trees that died emphasizes the importance of lightning and wind (excluding the 1954 hurricane) in comparison to all other mortality both during the period immediately following logging and in later years after the effects of tree injury and drastic change in environment have diminished. If the 11 dead trees with no record of cause are eliminated from the tabulation, trees that died from causes other than lightning and wind are 47 percent of the total for seed trees and 7 percent of the total for insurance trees. It is apparent that losses from lightning and wind continue over long periods of time and account for over 90 percent of all losses after the seedling stands are established.

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[3] McCulley, Robert D. Wet-weather logging may damage seed trees. Virginia Forests 5(5): 6. 1950.

Table 1.--Suspected cause of mortality for seed trees and insurance trees

Suspected cause of mortality	Seed trees (8 per acre)	Insurance trees (2 per acre)
	Number	Number
Fire	[1] 15	--
Logging and insects	25	2
No apparent cause	17	1
No record of cause	7	4
Lightning	34	29
Wind (excluding 1954 hurricane)	29	14
Total	127	50

[1] One half of the seed-tree areas were burned.

RATE OF MORTALITY

The period of record varied from 1.3 to 5.8 years for stands of 8 seed trees and from 0.4 to 4.7 years for insurance trees. In all there were 14 seed-tree areas and 18 insurance-tree areas under observation.

In order to get all data on a comparable basis, particularly in view of the unequal periods of time involved, the period that a stand stood undisturbed in tenths of years and the acreage were used to compute units of 100 acres for 1 year. This area-time unit is used to compare the relative rates of mortality for each compartment (table 2). As the average seed-tree and insurance-tree areas are 35 and 37 acres respectively, the period of observation can be estimated for each area in the table. For example the first unit of observation is 1.91 hundred-acre years, or approximately 35 acres for 5.5 years.

The use of a fire treatment at the time of regeneration was a major comparison in the regeneration experiment. From our experience the post-logging fire increases the number of seed trees that die. More than 10 trees died per 100 acres per year on burned compartments, while the rate was less than 5 on unburned areas. It seems improbable that lightning and wind mortality are related to the fire treatments. When these causes are eliminated, 4.9 trees died per 100 acres per year on burned, and 2.7 trees on unburned areas. Mortality from all causes other than lightning and wind was increased 2.2 trees per 100-acre-year unit, or 81 percent by the burning treatment.

Table 2.--Basic record on 32 areas showing unit of observation, number of trees dying, and rate of mortality per 100 acres per year for seed trees and insurance trees

Stand description	Unit of observation, 100 acres	Trees dying	Mortality per 100 acres per year	
			All causes	Excluding wind and lightning
	Years	Number	Number of trees	Number of trees
8 seed trees per acre (not burned)	1.91	8	4.2	2.6
	1.61	4	2.5	1.2
	1.03	7	[1] 6.8	3.9
	.83	6	7.2	2.4
	.78	2	2.6	2.6
	.72	5	6.9	6.9
	.59	3	[1] 5.1	0.0
Subtotal or average	7.47	35	[1] 4.7	2.7
8 seed trees per acre (burned)	2.17	21	9.7	6.9
	2.06	15	7.3	5.3
	1.61	15	[1] 9.3	0.0
	1.17	18	[1] 15.4	1.7
	.89	10	11.2	9.0
	.58	11	[1] 19.0	10.3
	.42	2	4.8	4.8
Subtotal or average	8.90	92	[1] 10.3	4.9
Total all seed trees	16.37	127	[1] 7.8	3.9
2 insurance trees per acre selected from strips	2.12	2	0.9	0.0
	2.11	7	3.3	0.5
	1.46	1	0.7	0.7
	1.35	5	3.7	1.5
	1.25	3	2.4	0.0
	1.02	5	4.9	0.0
	.27	0	0.0	0.0
	.19	1	5.3	5.3
Subtotal or average	9.77	24	2.5	0.5
2 insurance trees per acre selected from seed trees	.93	8	[1] 8.6	1.1
	.88	6	[1] 6.8	1.1
	.63	3	[1] 4.8	0.0
	.60	2	[1] 3.3	0.0
	.55	2	3.6	0.0
	.23	2	[1] 8.7	0.0
	.23	2	[1] 8.7	0.0
	.23	0	0.0	0.0
	.19	1	5.3	0.0
	.14	0	0.0	0.0
Subtotal or average	4.61	26	[1] 5.6	0.4
Total all insurance trees	14.38	50	[1] 3.5	0.5

[1] Includes wind mortality

The insurance trees were expected to stand for long periods, perhaps until the end of the rotation. Thus, thrift and freedom from injury were important considerations when they were selected. Within this group of trees, lightning and wind accounted for 3 of the 3.5 trees that died per reporting unit. This rate of mortality will continue and presumably will not diminish until the trees are all gone.

The occasional wind storms that have destroyed seed trees generally occurred along the squall fronts of violent summer storms. The appearance of broken trees indicates that twisting of the tree was the cause of failure. The damage occurred in small streaks over the area, with most trees breaking or being upturned by winds from the west and southwest. Because of the nature of the storms, wind damage has been erratic, occurring on only 5 of the 14 seed-tree areas and 6 of the 18 insurance-tree areas. Where wind damage is a factor, the rate per reporting unit is high because normally 2 or more trees were destroyed by a storm (fig. 1).

In the tabulation of insurance tree stands (table 2), the first eight entries are from compartments in which the trees were selected from uncut strips. The strips contained trees of all crown classes, and insurance trees were selected for thrift and small volume. There was no wind damage recorded in these eight stands for relatively long periods. It is probable that the violent summer storms would be less damaging to stands of younger and smaller seed trees.

LIGHTNING AND OTHER MORTALITY

Two distinct forest conditions were represented on the Experimental Forest before cutting. One was an overmature old-field pine stand growing in well-drained terrace soil, and the other was forest-grown pine with two age classes: 60 to 80 years, and over 100 years. Fire treatment was used on one-half of the compartments in both the forest grown and old-field stands, so that an over-all comparison of mortality between these two forest conditions is not influenced by the burning treatment.

When the data are arranged by stand origin and number of trees (table 3) the relative importance of lightning, wind, and all other mortality is shown for the period of regeneration with seed trees and during later years with insurance trees.

On areas cut to seed trees the loss was less than 1 percent of all trees per year for the regeneration period. If 800 seed trees were left on 100 acres for 4 years and all mortality could be concentrated in one area of 4 acres, then 31 trees would be dead and only 1 would remain. Of the 4 acres with dead trees, the mortality by area might be distributed as follows: 2 acres to injury and drastic change in environment, 1 acre to lightning, and 1 acre to wind. After stands were reduced to insurance trees, the percent of annual rate of mortality increased to 1.75 percent. With 200 trees left on 100 acres for 4 years, 14 trees may be expected to die or the equivalent of 7 acres of insurance trees. Lightning now has accounted for mortality on 4 acres, wind on 2 acres, and all other causes on 1 acre.

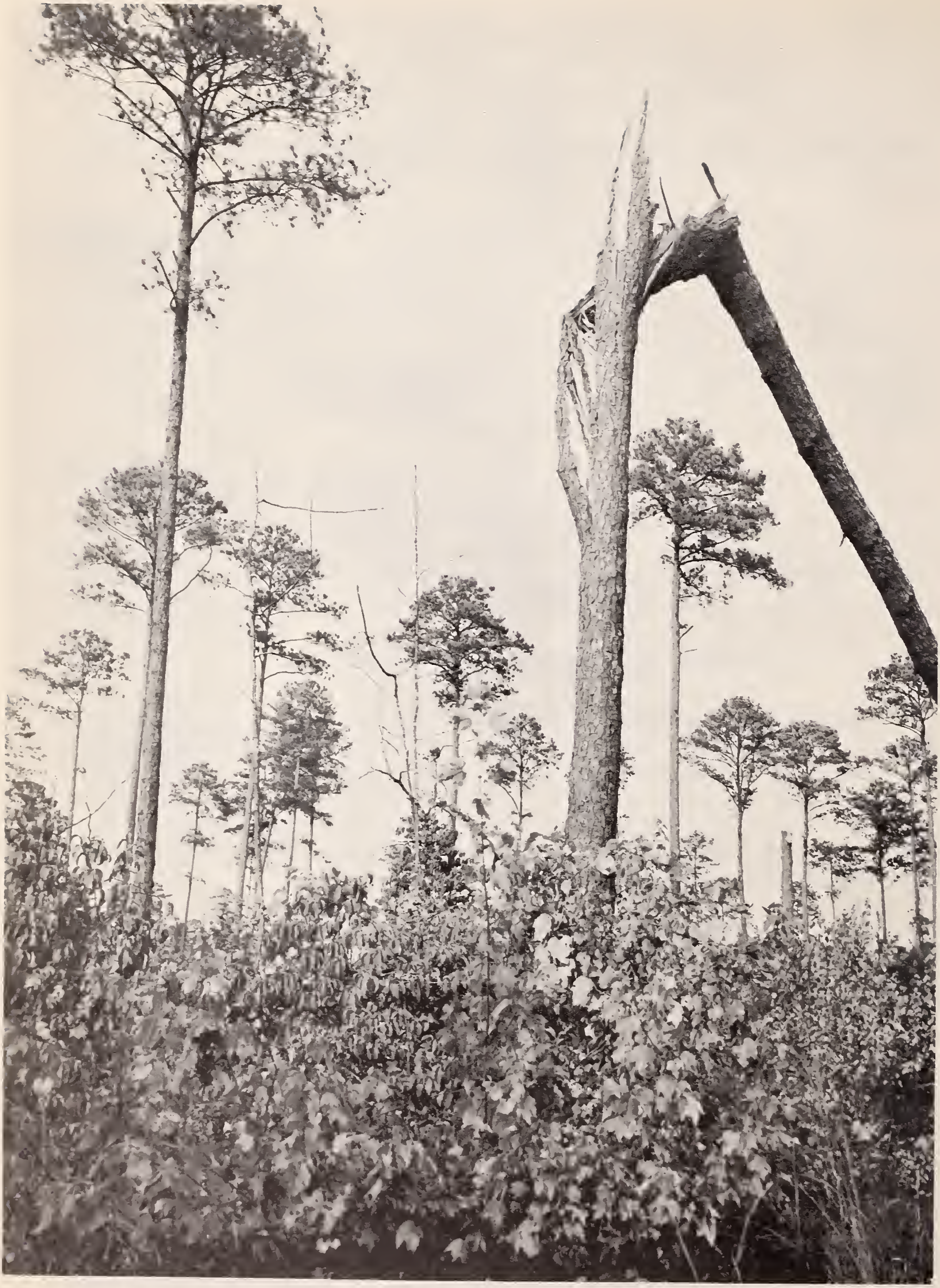

Figure 1.--A seed tree twisted off by summer storm.

Table 3.--Mortality of pine leave trees per 100 acres per year during regeneration (seed trees) and young stand development (insurance trees)

Stand description	Lightning	Wind	All other causes	All causes
	Number	Number	Number	Number
8 seed trees per acre				
Old field	2.1	2.5	2.8	7.4
Forest grown	2.1	0.5	5.8	8.4
Seed trees, average	2.1	1.8	3.9	7.8
2 insurance trees per acre				
Old field, from seed trees	2.2	2.8	0.0	5.0
Forest grown, from seed trees	2.1	3.2	0.7	6.0
Forest grown, from strips	1.9	0.0	0.6	2.5
Insurance trees, average	2.0	1.0	0.5	3.5

This example is used to emphasize the constant attrition of large pines by lightning on an area basis. With many trees, the loss would be relatively small, but with progressively fewer numbers of trees per unit area the mortality rate increases until with 1 seed tree per acre all trees on 100 acres might theoretically be killed in a period of 50 years.

Wahlenberg[4] reported the incidence of lightning for the United States to be 10 strokes per square mile of land area each year. With these data indicating 2 strokes per 100 acres per year, the incidence of lightning would be 12.8 strokes per square mile, or slightly higher than the nation's average.

Trees were killed by lightning on 11 of the 14 seed-tree areas and 11 of the 18 insurance-tree areas. Six of the 10 areas that did not have a lightning-struck tree contained standing trees for only 0.7 years or less. Of the 21 stands that contained trees for 1 year or more, 17 stands, or 80 percent, had trees killed by lightning.

The data on wind and other causes emphasize that wind damage is erratic. Heavy wind damage occurred among large insurance trees selected from the seed-tree stands, but no wind damage was found in smaller insurance trees selected from strip cuttings. The high rate of mortality from causes other than wind and lightning occurred immediately following logging during the regeneration period. After the stands were regenerated and reduced to insurance trees, the mortality rate from causes other than wind and lightning was greatly reduced.

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[4] Wahlenberg, W. G. Longleaf pine. 429 pp., illus. Charles Lathrop Pack Forestry Foundation, Washington, D. C. 1946.

HURRICANE DAMAGE

On October 15, 1954, Hurricane Hazel passed over a wide area of the coastal plain. It was the first severe hurricane to strike the study area in many decades. Severe damage occurred in both seed-tree and insurance-tree stands. The even-aged management areas on the Experimental Forest were mostly in one block, permitting the south and southeasterly winds to sweep through the stands. Wind speeds were estimated between 80 and 100 miles per hour in this storm. Because of a scarcity of rainfall the trees were firmly rooted in dry soil, and most of the damaged trees broke under compression, usually within the first 2 logs of the 4- and 5-log trees. On wet areas a few trees upturned. Some of the trees left standing sustained internal damage and have broken with relatively light winds since the storm.

Damage was related to tree size and origin of the original stands. Large seed trees that were selected from old-field stands suffered the most severe damage. Smaller, forest-grown, insurance trees selected from seed trees were less heavily damaged, and the smallest forest-grown insurance trees selected from strip cuttings were damaged the least (fig. 2). This is the same relationship of mortality to stand origin and tree size as shown for normal wind damage in table 2.

The normal rate of mortality of seed-tree stands has been shown to be from 1 to 2 percent of the trees per year. In comparison, the losses from this one storm ranged from 8 to 78 percent of the board-foot volume and very nearly the same percentage losses apply to the number of trees (fig. 3).

DISCUSSION

The insurance-tree plan of leaving 2 trees per acre for an extended period of time is not recommended. Two trees per acre are usually inadequate to reseed an area following a wildfire, and wind and lightning progressively reduce this number. The individual surviving trees may grow rapidly in volume and value but within the young even-aged stands a small volume of quality saw-log material will be difficult to remove as products other than pulpwood until the young stand attains saw-log size. If this period is 35 years, lightning will reduce the number of insurance trees by 35 percent. During the first 15 to 20 years the insurance trees are also vulnerable to normal winds and, of course, hurricanes. If the hazards are so high that insurance is needed, many seed trees or one of the selection systems should be used, or provision should be made to plant areas destroyed by wildfires.

The timber value lost in seed trees during the regeneration period should be considered a cost of the seed-tree method. Tractor logging and drastic cultural treatments (disking, burning, and bulldozing) that improve seedbed conditions and reduce competition may increase the mortality of seed trees, but these measures are often essential to establish well distributed stands of seedlings. The number of seed trees that die from injury can be reduced by logging supervision and good judgment in the choice of cultural treatment. In any combination of logging method and cultural treatment the best

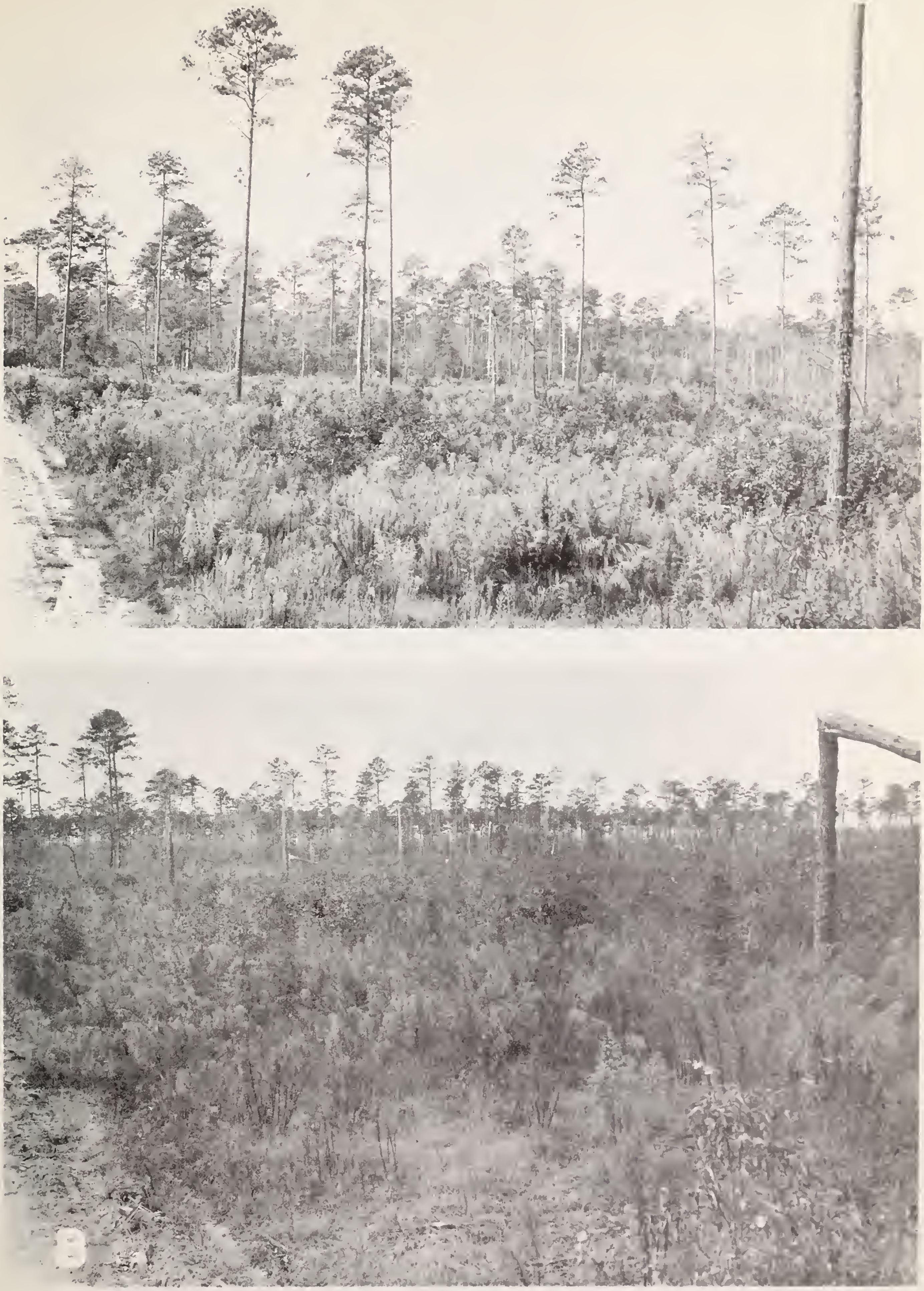

Figure 2.--A, Stand of 2 insurance trees per acre pictured October 1953, before the hurricane. B, Same stand October 1954, after the storm, showing typical breakage of main boles.

opportunity to reduce the mortality of seed trees will come with shortening the period that seed trees remain on the area.

Reducing the period of regeneration also permits the felling and removal of the large trees with a minimum of damage to the seedling stands. With planned skidroads and directional felling, seed trees can be removed from any young seedling stand with little damage except at yarding and loading points. If the trees are removed after seedfall, these areas generally reseed satisfactorily.

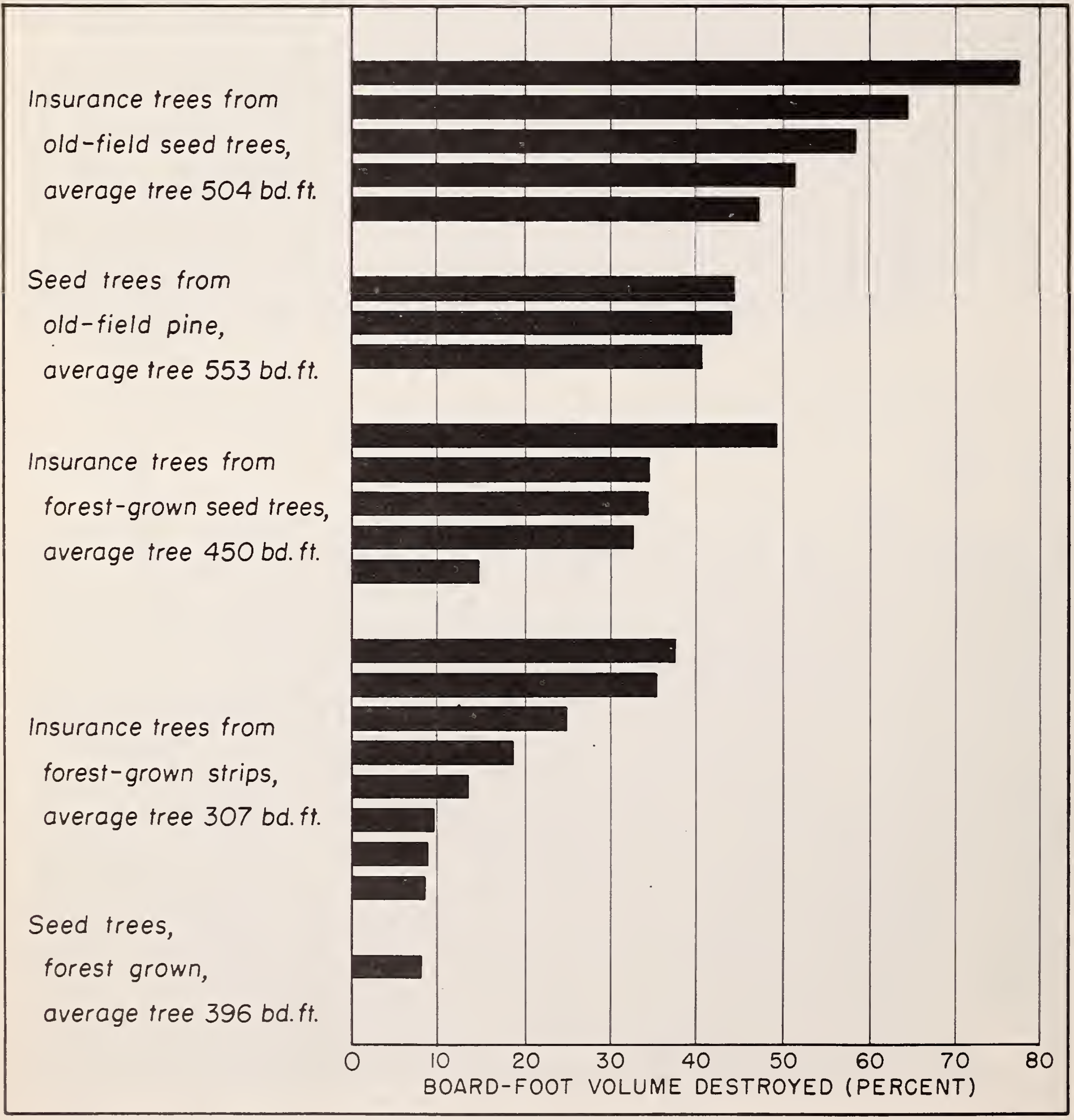

Figure 3.--Percent of board-foot volume of pine seed or insurance trees destroyed on individual management areas by Hurricane Hazel.

The effective regeneration period for loblolly pine on cutover lands in the coastal plain is short, generally occurring the first year and seldom extending beyond 3 years. If an operable volume of the best trees is left to furnish seed and these trees are removed as soon as the effective regeneration period is over, the value of trees lost is small compared to costs of alternative methods of artificial seeding and planting.

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SUMMARY

The 8 best seed-producing pines, or one-quarter of the pine stands, were left to reseed each acre when the timber was harvested from mature stands. Crawler tractors were used in logging. Cultural operations designed to improve the seedbed and reduce competition from undesirable plants were used on some of the areas. One-half of the logged areas were burned and one-quarter disked to improve the seedbed. Some seed trees were injured during the logging and in the burning operations. Eight percent of the seed trees were severely damaged in logging and 5 percent of the injured trees died.

A record of mortality showed that less than 1 percent of the seed trees died per year for all seed-tree areas during the average regeneration period of 3.3 years. The increased seed-tree mortality due to the burning treatment was approximately equal to the average lightning mortality for the period. A number of trees died with no external evidence of injury. Lightning and wind caused over half the mortality during the period the trees had to stand to reseed the area.

Following successful regeneration by the seed-tree and strip methods, all merchantable pine trees were cut except 2 sound and thrifty trees per acre left as an insurance measure. Few if any of these trees were injured by the relogging. During the 2.1-year period of record, 1.75 percent of the insurance trees died per year. Over 90 percent of the mortality was a result of lightning and wind.

The rates of mortality computed for 100 acres of seed trees or insurance trees for a period of 1 year indicate that lightning mortality is constant for a given area of land. Mortality caused by wind, tree injury, and other causes is proportional to the number of trees per unit area. The insurance-tree plan of leaving 2 trees per acre for an extended period of time is not recommended. Two trees per acre are usually inadequate to reseed an area following wildfire, and wind and lightning progressively reduce this number.

On October 15, 1954, a full-blown hurricane struck the forest, and seed-tree and insurance-tree stands were severely damaged. The loss from this one storm dwarfs all other mortality. During the 6 years 1948-1954, the annual mortality per 100 acres was 7.8 trees dying in seed-tree stands and 3.5 trees dying in insurance-tree stands. In comparable stands 239 seed trees and 65 insurance trees were destroyed on the average 100 acres by this hurricane.

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